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REFERENCE ONLY

Automatic Aging Calculation for Transducer Piezoelectric Ceramic

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Report Documentation Page

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Technical Memorandum

Automatic Aging Calculation
for Transducer Piezoelectric Ceramic

Date 24 June 1985

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ABSTRACT

The "RING" computer program was developed to calculate the aging.rate of piezoelectric ceramic materials. The program computes the percent aging rate for ceramic capacitance, resonant frequency, and coupling coefficient as a function of logarithmic time decades. Program options enable the user to store and edit data, perform statistical analyses, and display printed or plotted ceramic properties.

ADMINISTRATIVE INFORMATION

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INTRODUCTION

A computer program was developed to calculate the aging rate of piezoelectric ceramic materials. The program, called "RING", computes the percent aging rate for ceramic capacitance, resonant frequency, and coupling coefficient as a function of logarithmic time decades. The program is useful for predicting ceramic behavior over time.

Program applications include both circular ring and cylindrical tube ceramic shapes. The data to be entered includes the ceramic serial number, capacitance, dissipation factor, frequency data, and temperature for two different days since poling. Program options enable the user to store and edit data, perform statistical analyses, and display printed or plotted ceramic properties. A computer listing of the program is presented in the appendix of this technical memorandum.

PROGRAM INSTALLATION

The "RING" program operates on the Hewlett-Packard HP 9845 desktop computer. The tape cassette should be inserted into the right hand tape drive unit (from user perspective). The following executive commands are used to initialize, run, and terminate the program. Each example is divided into three parts. The first column lists the typed command. The second column shows the console key(s) to be pressed. The third column describes the action taken by the program.

COMMAND	CONSOLE KEY	COMMENT
GET "RING"	EXEC RUN	Executes the "RING" program
CAT	EXEC	Lists all data files
DUMP GRAPHICS	EXEC	Hard copy print of a plot
	STOP	Terminates the "RING" program
	STOP RUN	Terminates a session and restarts the program

PROGRAM OPTIONS

The program operates from a main options list. Each time the user selects an option, the program performs the requested function and returns to the main options list. The following paragraphs discuss the usage of each of the main options.

1. CREATE DATA FILE FOR RING STORAGE

This option creates a data file on tape on which ceramic ring data may be stored using Option 2. The user enters the file title (up to 6 characters in length) and the maximum number of rings for which storage is to be allocated. Up to 500 rings may be stored on a single file. The size of a data file should be specified greater than that used initially if subsequent ring data are added to the file.

The program then attempts to create the file on the tape or disk. If no tape or disk error occurs, the user enters an up to 80 character file title/information string indicating the contents of the file. The ring original poling data is then entered (up to 32 characters in length). This data is stored in the file, and the program returns to the main options list. See the Option 1 example in the Appendix of this report for creating a data file.

2. STORE RING DATA IN DATA FILE

Once a file has been created using Option 1, the user may store individual ring data in the file. First, the user selects the data file in which the ring data is to be stored. Then, provided that the file is not already filled, the user enters the ring serial number. The input data depends upon the types of measurements taken on the ceramic rings, which vary with transducer model. Currently the program is set up to accept data for the TR-317 or TR-155 transducers (ceramic ring or tube data). For the TR-317 transducer two sets of the following data are entered:

6

Days since poling
CAP   –   Capacitance in picofarads at 1 KHz
K   –   Coupling Coefficient (K_{31}, "Hoop Mode")
DF   –   Dissipation Factor at 1 KHz
FR   –   Ring Resonant Frequency, "Hoop Mode", KHz
TEMP –   Air Temperature in degrees Fahrenheit

For the TR-155 transducer two sets of the following data are entered:

Days since poling
CAP   –   Capacitance in picofarads at 1 KHz
DF   –   Dissipation Factor at 1 KHz
FM   –   Frequency of Maximum Admittance KHz
FN   –   Frequency of Minimum Admittance KHz
TEMP –   Air Temperature in degrees Celsius

The data is stored in the data file, and the program returns to the main options list. The Option 2 examples in the Appendix show data storage formats for both the TR-317 and TR-155 model transducers.

3. <u>PRINT RING CATALOG FOR THE CURRENT DATA FILE</u>

If the user wishes to print a catalog of the serial numbers of rings stored on the current data file, he selects Option 3. The catalog may be printed on the CRT or the printer. The file name, the title string, and the poling date string are printed, followed by a list of the ring serial numbers stored in the file (See the Appendix under the Option 3 example for displaying a ring catalog). The program then returns to the main options list.

4. <u>EDIT DATA STORED IN DATA FILE</u>

Data that has been previously stored in a data file may be changed using Option 4. A list of data edit options is printed as follows:

EDIT OPTIONS:

1. Print serial number catalog for file
2. Edit ring
3. Purge ring
4. Enter new title string
5. Enter new poling date
6. Return to main options

Any changes made are stored in the data file. Thus, if a ring is purged using edit Option 3, that data is no longer accessible for any purpose, because it is deleted from the data file, not just from the statistical calculation (see main Option 6). When edit Option 6 is selected, data editing is completed, and the program returns to the main options list. The Option 4 example located in the Appendix gives a few examples of this option.

5. CALCULATE STATISTICS AND PRINT RING DATA TABLE

This option calculates statistics and prints the file data on the CRT or the printer. The user selects the file, and where the table is to be printed. The mean, standard deviation, and minimum and maximum of CAP, K, and FM are printed for both days since poling. If Option 6 has been exercised to delete a ring from the statistical calculations, an asterisk is placed next to the ring serial number. After the table has been printed, the program returns to the main options list (See Option 5 example in the Appendix).

6. DELETE A RING FROM THE STATISTICAL CALCULATIONS

Once a table has been printed using Option 5, the user may delete a ring from the statistical calculations. The user enters the ring serial number, and the program returns to the main options list (See Option 6 example in the Appendix).

7. RESTORE A RING TO THE STATISTICAL CALCULATIONS

A ring that has been deleted from the statistical calculations using Option 6 may be restored to the calculations using Option 7. The ring serial number is entered, and the program returns to the main options list. See the Option 7 example in the Appendix of this report.

8. PLOT INDIVIDUAL RING DATA

This option plots on the CRT, the CAP, FR, and K data for an individual ring on a logarithmic time scale. The user selects the file and ring serial number, and the plot is automatically scaled and drawn on the CRT. The actual CAP, FR, and K data points are denoted by an X. A line is drawn through the data points, and the slope of the line is printed, indicating the percent change per logarithmic decade for each data type (See Option 8 example in the Appendix). After the plot is drawn, the program pauses. The user presses CONT when he wishes to return to the main options list. A ring which was deleted from statistical calculations using Option 6 may be plotted under this option.

9. MAKE BAR PLOT OF COMPOSITE CAP, K, OR FR DATA

A bar graph of the CAP, K, or FR data for each data set is plotted on the CRT. Rings which have been deleted from the statistical calculations do not appear on the bar chart. When the plot for the first data set has been made, the program pauses. When CONT is pressed, the plot for the second data set is made, and the program pauses again. The user then presses CONT to return to the main options list. See the Appendix under the Option 9 example for a sample bar plot.

APPENDIX

"RING" PROGRAM OPTION EXAMPLES

The following computer listing is a sample session illustrating the use of options with the "RING" program. Each program option is demonstrated. User responses are denoted with a caret (>) preceding the response. Additional comments are inserted to clarify the input data.

OPTION 1 EXAMPLE:

```
    ENTER OPTION NUMBER (1-9)
 > 1
    ENTER FILE TITLE AND MASS STORAGE DEVICE
 > RING1
    ENTER NUMBER OF RINGS TO ALLOCATE STORAGE FOR (1-500)
 > 6
    ATTEMPTING TO CREATE FILE RING1,8,128
    ENTER FILE TITLE STRING (UP TO 80 CHARACTERS)
 > TR155G-BQ SAMPLE DATA
    ENTER POLING DATE (UP TO 32 CHARACTERS)
 > 1-15-85
```

OPTION 2 EXAMPLE: TR-155

```
    ENTER OPTION NUMBER (1-9)
  > 2
    PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE
  >
    ENTER SERIAL NUMBER (NUMERIC ONLY, >0)
  > 50830224
    ENTER 1 FOR TR-317 DATA, 2 FOR TR-155 DATA
  > 2
    ?
  > 8          Days since poling  ─┐
    ?
  > 30549      CAP                 │
    ?
  > .002       DF                  │
    ?                                   DATA SET 1
  > 16901      FM                  │
    ?
  > 18822      FN                  │
    ?
  > 22         TEMP               ─┘
    ?
  > 22         DAYS SINCE POLING  ─┐
    ?
  > 29961      CAP                 │
    ?
  > .002       DF                  │
    ?                                   DATA SET 2
  > 16968      FM                  │
    ?
  > 18847      FN                  │
    ?
  > 22         TEMP               ─┘
    PRESS CONT TO ENTER DATA FOR ANOTHER RING; ENTER 0 TO RETURN TO OPTIONS LIST.
```

OPTION 2 EXAMPLE: TR-317

```
    ENTER OPTION NUMBER  1-9
 > 1
    ENTER FILE TITLE AND MASS STORAGE DEVICE
 > RING2
    ENTER NUMBER OF RINGS TO ALLOCATE STORAGE FOR (1-500)
 > 50
    ATTEMPTING TO CREATE FILE RING2,55,128
    ENTER FILE TITLE STRING (UP TO 80 CHARACTERS)
 > TR-317 SAMPLE DATA
    ENTER POLING DATE (UP TO 32 CHARACTERS)
 > 4-12-85
    ENTER OPTION NUMBER (1-9)
 > 2
    PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE
 >
    ENTER SERIAL NUMBER (NUMERIC ONLY, >0)
 > 632148
    ENTER 1 FOR TR-317 DATA, 2 FOR TR-155 DATA
 > 1
    ?
 > 129        Days since poling  ─┐
    ?
 > 1516       CAP                 │
    ?
 > .3291      K                   │
    ?
 > .0013      DF                  ├── DATA SET 1
    ?
 > 14729      FR                  │
    ?
 > 75         TEMP               ─┘
    ?
 > 49         Days since poling  ─┐
    ?
 > 1536       CAP                 │
    ?
 > .3340      K                   │
    ?
 > .0013      DF                  ├── DATA SET 2
    ?
 > 14695      FR                  │
    ?
 > 75         TEMP               ─┘
    PRESS CONT TO ENTER DATA FOR ANOTHER RING; ENTER 0 TO RETURN TO OPTIONS LIST.
```

OPTION 3 EXAMPLE:
```
    ENTER OPTION NUMBER (1-9)
 > 3
    HARDCOPY PRINTOUT (Y or N)?
 > Y
    FILE: RING1
    TR155G-BQ SAMPLE DATA
    POLING DATE: 1-15-85

    FILE RING1 CONTAINS DATA FOR THE FOLLOWING RING SERIAL NUMBERS:

    50830224          50830321          50880103          50880115
    50880413          50900202
```

OPTION 4 EXAMPLE:

a. Print ring serial number from RING 1 data file.

```
   ENTER OPTION NUMBER  (1-9)
>  4
   ENTER FILE NAME WITH MASS STORAGE DEVICE
>  RING1
   ENTER EDIT OPTION NUMBER (1-6)
>  1
   HARDCOPY PRINTOUT (Y or N)?
>  Y
   FILE: RING1
   TR155G-BQ SAMPLE DATA
   POLING DATE: 1-15-85

   FILE RING1 CONTAINS DATA FOR THE FOLLOWING RING SERIAL NUMBERS:

   50830224          50830321          50880103          50880115
   50880413          50900202
```

b. Create a new title string.

```
   ENTER EDIT OPTION NUMBER (1-6)
>  4
   ENTER NEW TITLE STRING  (UP TO 80 CHARACTERS)
>  TR-155G/BQ EDIT
```

c. Make the following changes to the first data set of ring #50830224:

```
                    CAP  = 30500
                    K    = .20
                    FM   = 17000
                    FN   = 19000
   ENTER EDIT OPTION NUMBER (1-6)
>  2
   ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)
>  50830224
   ENTER Y or N                     Change values for time 1?
>  Y
   PRESS CONT, OR ENTER A NEW VALUE  Days since poling
>
   PRESS CONT, OR ENTER A NEW VALUE  CAP
>  30500
   PRESS CONT, OR ENTER A NEW VALUE  K
>  .2
   PRESS CONT, OR ENTER A NEW VALUE  DF
>
   PRESS CONT, OR ENTER A NEW VALUE  FM
>  17000
   PRESS CONT, OR ENTER A NEW VALUE  FN
>  19000
   PRESS CONT, OR ENTER A NEW VALUE  TEMP
>
   ENTER Y or N                     Change values for time 2?
>  N
   ARE VALUES CORRECT  Y or N)?      Updated values are listed on monitor.
>  Y
```

OPTION 5 EXAMPLE:

ENTER OPTION NUMBER (1-9)
> 5
PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE
>
PRINT HARD COPY (Y or N)?
> Y

FILE: RING1
TR-155G/BQ EDIT
POLING DATE: 1-15-85

RING	DAY	CAP	K	DF	FM	FN	T
50830224	008	30500	.2000	.0020	17000	19000	72
	022	29961	.1895	.0020	16968	18847	72
50830321	008	31259	.1920	.0020	16861	18758	72
	022	30546	.1877	.0020	16958	18816	72
50880103	008	30377	.1850	.0020	17011	18843	72
	022	29819	.1815	.0010	17088	18888	72
50880115	008	30503	.1902	.0020	16971	18859	72
	022	29919	.1851	.0010	17058	18896	72
50880413	008	30613	.1919	.0020	16971	18879	72
	022	30046	.1868	.0010	17058	18916	72
50900202	008	30612	.1910	.0020	16981	18880	72
	022	30022	.1867	.0010	17068	18926	72

CAP	MIN	MAX	MEAN	STD DEV
FIRST DATA SET	30377	31259	30644	313.72472
SECOND DATA SET	29819	30546	30052.167	255.0415

K	MIN	MAX	MEAN	STD DEV
FIRST DATA SET	.18439628	.2	.1916989	.0048303313
SECOND DATA SET	.18151538	.18945552	.18621573	.0027126622

FM	MIN	MAX	MEAN	STD DEV
FIRST DATA SET	16861	17011	16965.833	53.816039
SECOND DATA SET	16958	17088	17033	55.407581

```
            ENTER OPTION NUMBER (1-9)
        >  6
            ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)
        >  50830224
```

Verify ring # 50830224 deleted from ring statistical calculations

```
  ENTER OPTION NUMBER  1-9)
>  5
  PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE
>
  PRINT HARD COPY (Y or N)?
>  Y
```

```
  FILE: RING1
  TR-155G/BQ EDIT
  POLING DATE: 1-15-85
```

RING	DAY	CAP	K	DF	FM	FN	T
50830224*	008	30500	.2000	.0020	17000	19000	72
	022	29961	.1895	.0020	16968	18847	72
50830321	008	31259	.1920	.0020	16861	18758	72
	022	30546	.1877	.0020	16958	18816	72
50880103	008	30377	.1850	.0020	17011	18843	72
	022	29819	.1815	.0010	17088	18888	72
50880115	008	30503	.1902	.0020	16971	18859	72
	022	29419	.1851	.0010	17058	18896	72
50880413	008	30613	.1919	.0020	16971	18879	72
	022	30046	.1868	.0010	17058	18916	72
50900202	008	30612	.1910	.0020	16981	18880	72
	022	30022	.1867	.0010	17068	18926	72

CAP	MIN	MAX	MEAN	STD DEV
FIRST DATA SET	30377	31259	30672.8	341.77215
SECOND DATA SET	29819	30546	30070.4	280.73885

K	MIN	MAX	MEAN	STD DEV
FIRST DATA SET	.18499628	.19203305	.19003868	.0029142182
SECOND DATA SET	.19151538	.18774077	.18556777	.0024595313

FM	MIN	MAX	MEAN	STD DEV
FIRST DATA SET	16861	17011	16959	57.183914
SECOND DATA SET	16958	17088	17046	50.695167

Ring #50830224 was omitted from the ring statistics calculations via Option 6.
Compare the results with those in the Option 5 example.

OPTION 7 EXAMPLE:

        ENTER OPTION NUMBER 1-9)
      > 7
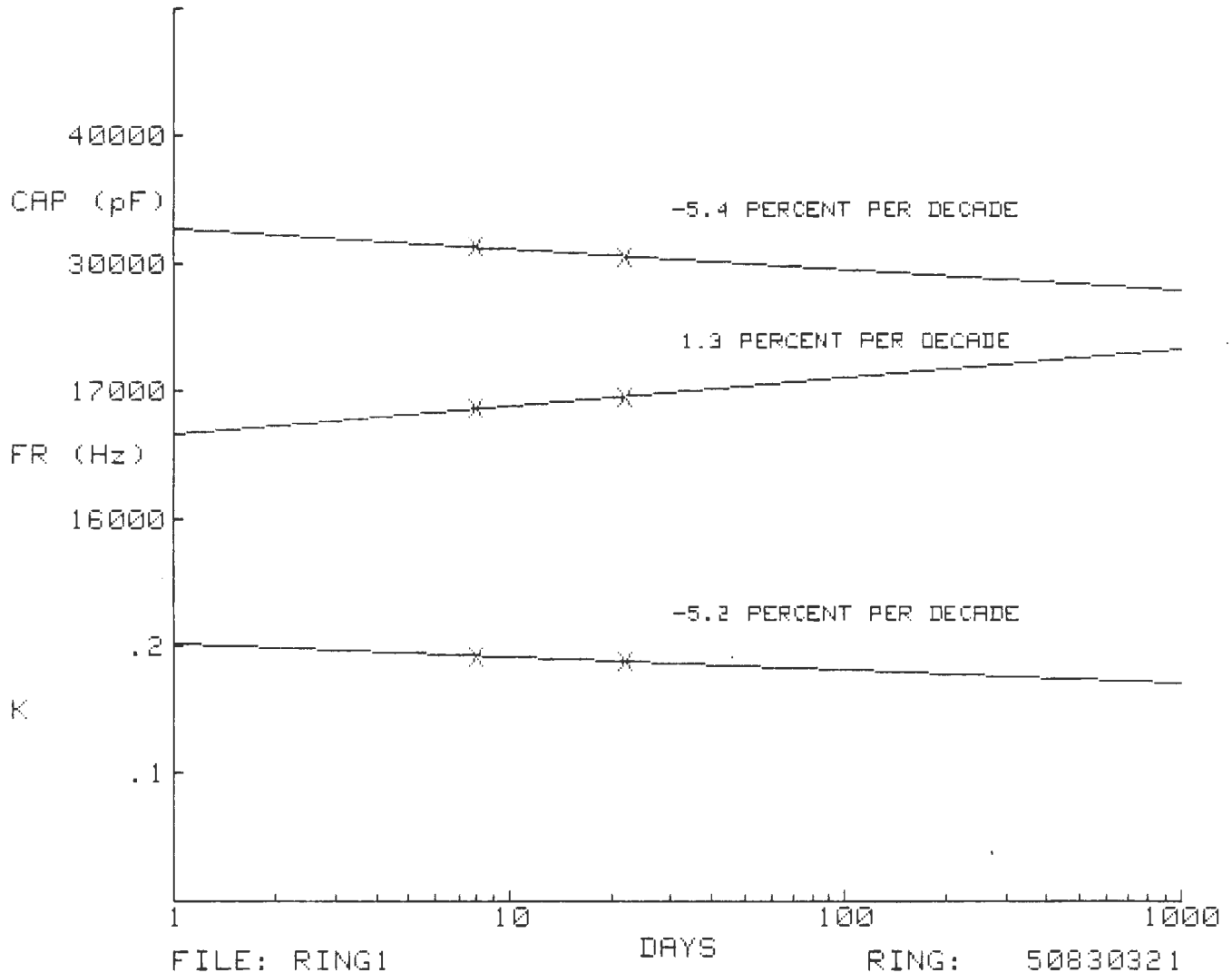   ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)
      > 50830224

    OPTION 8 EXAMPLE:

  ENTER OPTION NUMBER (1-9)
> 8
  PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE
>
  ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)
> 50830321
> DUMP GRAPHICS

FILE: RING1   DAYS   RING: 50830321

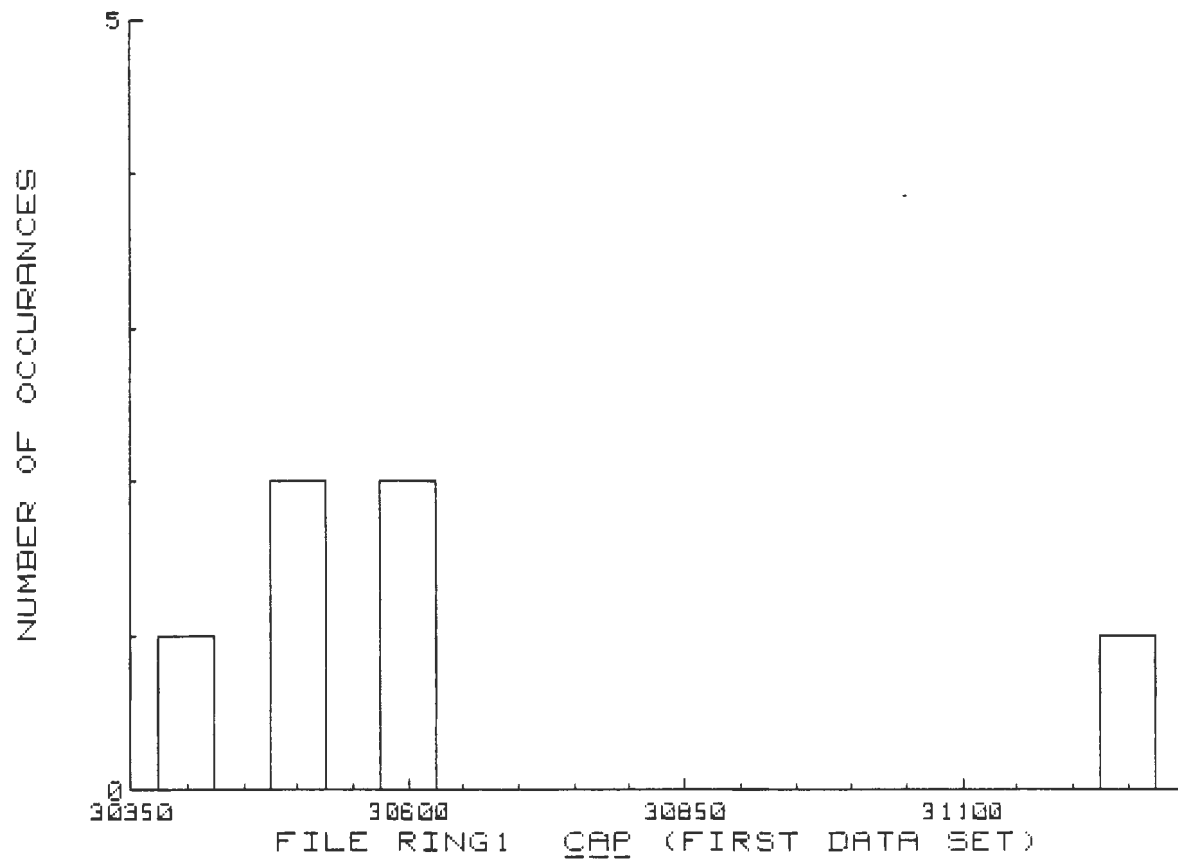OPTION 9 EXAMPLE:

```
ENTER OPTION NUMBER (1-9)
9
ENTER 1 TO PLOT CAP; 2 TO PLOT K; 3 TO PLOT FR.
1
DUMP GRAPHICS
```

```
10    ! RING - 28 MAY 1985
20    OPTION BASE 1
30    DIM Ser(500),Dat(2,7),Dat$(7),Title$[80],Ckf(500,6),Stat(6,4),Nostat(500),D
ate$[32]
40    MAT READ Dat$
50    DATA DAYS SINCE POLING,CAP,K,DF,FM,FN,T
60 Opt:   Opt=0
70    PRINT LIN(3);"MAIN OPTIONS:"
80    PRINT "   1. CREATE DATA FILE FOR RING STORAGE;"
90    PRINT "   2. STORE RING DATA IN DATA FILE;"
100   PRINT "   3. PRINT RING CATALOG FOR THE CURRENT DATA FILE;"
110   PRINT "   4. EDIT DATA STORED IN DATA FILE;"
120   PRINT "   5. CALCULATE STATISTICS & PRINT RING DATA TABLE;"
130   PRINT "   6. DELETE A RING FROM THE STATISTICAL CALCULATIONS;"
140   PRINT "   7. RESTORE A RING TO THE STATISTICAL CALCULATIONS;"
150   PRINT "   8. PLOT INDIVIDUAL RING DATA;"
160   PRINT "   9. MAKE BAR PLOT OF COMPOSITE CAP, K, OR FR DATA."
170   INPUT "ENTER OPTION NUMBER (1-9)",Opt
180   IF (Opt<1) OR (Opt>9) THEN Opt
190   ON Opt GOSUB Createfile,Datastore,Rcat,Dataedit,Table,Statdelete,Statrestor
e,Plot,Call_barplot
200   GOTO Opt
210 Createfile:  INPUT "ENTER FILE TITLE AND MASS STORAGE DEVICE",File$
220 Cf05:  INPUT "ENTER NUMBER OF RINGS TO ALLOCATE STORAGE FOR (1-500)",Nring
230   IF Nring<1 THEN Cf99
240   IF Nring>500 THEN Cf05
250   Recplus=INT(Nring/16)+1+(Nring MOD 16>0)
255   Nrec=Nring+Recplus
260   DISP "ATTEMPTING TO CREATE FILE ";File$;",";VAL$(Nrec);",128"
270   ON ERROR GOTO Cf10
280   CREATE File$,Nrec,128
290   GOTO Cf15
300 Cf10:  PRINT "ERROR";ERRN;"DURING ATTEMPT TO CREATE FILE ";File$
310   OFF ERROR
320   GOTO Cf99
330 Cf15:  OFF ERROR
340   PRINT "FILE ";File$;" CREATED"
350   INPUT "ENTER FILE TITLE STRING (UP TO 80 CHARACTERS)",Title$
355   INPUT "ENTER POLING DATE (UP TO 32 CHARACTERS)",Date$
360   ASSIGN #1 TO File$
370   REDIM Ser(Nring)
380   MAT Ser=(-1)
390   PRINT #1,1;Nring,Title$,Date$
400   PRINT #1,2
410   PRINT #1;Ser(*)
420   PRINT "FILE ";File$;" READY FOR STORING CERAMIC RING DATA"
430 Cf99:  RETURN
440   ! -----------------------------------------------------------------
450 Datastore: CALL Fileselect(File$,#1,Nring,Title$,Date$,Ser(*),Recplus,Nostat
(*))
460 Ds12: FOR P=1 TO Nring
470   IF Ser(P)=-1 THEN Ds15
480   NEXT P
490   PRINT "FILE ";File$;" IS FILLED - NO ADDITIONAL DATA CAN BE STORED"
500   GOTO Ds99
510 Ds15:  INPUT "ENTER SERIAL NUMBER (NUMERIC ONLY, >0)",Ser(P)
520   IF Ser(P)<=0 THEN Ds15
521 Ds20:   Kmode=0
522   INPUT "ENTER 1 FOR TR-317 DATA, 2 FOR TR-155 DATA",Kmode
523   ! "ENTER 1 IF K WILL BE DIRECTLY ENTERED, 2 TO CALCULATE K BASED ON FM & FN
",Kmode
526    IF (Kmode<1) OR (Kmode>2) THEN Ds20
528    MAT Dat=(0)
530   FOR I=1 TO 2
540   PRINT LIN(2);"ENTER DATA SET";I;"FOR TRANSDUCER RING";Ser(P);LIN(1)
550   FOR J=1 TO 7
```

```
551   IF (J=3) AND (Kmode=2) OR (J=6) AND (Kmode=1) THEN Ds30
560   PRINT "ENTER DATA SET";I;Dat$(J)
570   INPUT Dat(I,J)
580 Ds30: NEXT J
581   IF Kmode=1 THEN Ds40
582   Dat(I,3)=(Dat(I,6)^2-Dat(I,5)^2)/Dat(I,6)^2
583   PRINT "CALCULATED K VALUE FOR DATA SET";I;"=";Dat(I,3)
584   Dat(I,7)=Dat(I,7)*9/5+32
585   PRINT "TEMPERATURE CONVERTED TO";Dat(I,7);"deg F"
590 Ds40: NEXT I
600   PRINT #1,P+Recplus;Dat(*)
610   PRINT #1,2
620   PRINT #1;Ser(*)
630   READ #1,1;X
640   PRINT "DATA FOR RING";Ser(P);"HAS BEEN STORED IN FILE ";File$
650 Ds90: X=1
660   INPUT "PRESS CONT TO ENTER DATA FOR ANOTHER RING; ENTER 0 TO RETURN TO OPTI
ONS LIST.",X
670   IF X=1 THEN Ds12
680   IF X THEN Ds90
681    ASSIGN #1 TO *
682    ASSIGN #1 TO File$
690 Ds99: RETURN
700   ! ----------------------------------------------------------------
710 Dataedit: CALL Fileselect(File$,#1,Nring,Title$,Date$,Ser(*),Recplus,Nostat(
*))
720 De02: PRINT LIN(2);"EDIT OPTIONS:"
730   PRINT LIN(1);"  1. PRINT SERIAL NUMBER CATALOG FOR FILE ";File$
740   PRINT "  2. EDIT RING"
750   PRINT "  3. PURGE RING"
753   PRINT "  4. ENTER NEW TITLE STRING"
757   PRINT "  5. ENTER NEW POLING DATE"
760   PRINT "  6. RETURN TO MAIN OPTIONS"
770 De05: Edopt=0
780   INPUT "ENTER EDIT OPTION NUMBER (1-6)",Edopt
790   IF (Edopt<1) OR (Edopt>6) THEN De05
800   ON Edopt GOTO De10,De20,De60,De70,De80,De99
810 De10: CALL Ringcat(File$,Nring,Title$,Date$,Ser(*),Nostat(*))
820   GOTO De02
830 De20:   CALL Ringselect(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*))
840   IF Ring=0 THEN De02
850   READ #1,Ring+Recplus;Dat(*)
860   PRINT LIN(1);"CURRENT DATA FOR RING";Ser(Ring)
870   GOSUB De50
880 De28: FOR I=1 TO 2
890 De30: X$=""
900   PRINT "CHANGE VALUES FOR TIME";I;"(Y or N)?"
910   INPUT "ENTER Y or N",X$
920   IF X$="N" THEN De35
930   IF X$<>"Y" THEN De30
940   PRINT LIN(1);"PRESS CONT TO MAINTAIN DISPLAYED VALUE, OR ENTER A NEW VALUE"
;LIN(1)
950   FOR J=1 TO 7
960   PRINT "TIME";I;Dat$(J);" =";Dat(I,J)
970   INPUT "PRESS CONT, OR ENTER A NEW VALUE",Dat(I,J)
980   NEXT J
990 De35: NEXT I
1000 PRINT LIN(2);"REVISED VALUES FOR RING";Ser(Ring)
1010 GOSUB De50
1020 De40:X$=""
1030   INPUT "ARE VALUES CORRECT (Y or N)?",X$
1040   IF X$="Y" THEN De45
1050   IF X$<>"N" THEN De40
1060   GOTO De28
1070 De45: PRINT #1,Ring+Recplus;Dat(*)
1080   MAT Dat=(0)
```

19

```
1090    READ #1,Ring+Recplus;Dat(*)
1100    PRINT "EDITED VALUES HAVE BEEN STORED IN FILE ";File$
1110    GOTO De02
1120 De50: PRINT LIN(1);"    TIME 1",,"    TIME 2"
1130    FOR I=1 TO 7
1140    PRINT Dat(1,I),Dat$(I),Dat(2,I)
1150    NEXT I
1160    PRINT
1170    RETURN
1180 De60: CALL Ringselect(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*))
1190    IF Ring=0 THEN De02
1195    PRINT "RING";Ser(Ring);"PURGED"
1200    Ser(Ring)=-1
1210    PRINT #1,2;Ser(*)
1220    READ #1,1;Nring
1232    GOTO De02
1234 De70: PRINT "CURRENT TITLE STRING:"
1235    PRINT Title$
1236    INPUT "ENTER NEW TITLE STRING (UP TO 80 CHARACTERS)",Title$
1237    PRINT #1,1;Nring,Title$,Date$
1238    READ #1,1
1239    GOTO De02
1240 De80: PRINT "CURRENT POLING DATE: ";Date$
1242    INPUT "ENTER NEW POLING DATE (UP TO 32 CHARACTERS)",Date$
1244    PRINT #1,1;Nring,Title$,Date$
1245    READ #1,1
1247    GOTO De02
1250 De99: ASSIGN #1 TO *
1251    ASSIGN #1 TO File$
1256    RETURN
1260 ! ----------------------------------------------------------------
1270 Table: IF Opt=9 THEN Ta11
1275    CALL Fileselect(File$,#1,Nring,Title$,Date$,Ser(*),Recplus,Nostat(*))
1280 Ta10: X$=""
1290    INPUT "PRINT HARD COPY (Y or N)?",X$
1300    IF (X$<>"Y") AND (X$<>"N") THEN Ta10
1310    PRINTER IS 16*(X$="N")
1320    PRINT LIN(2);"FILE: ";File$
1322    PRINT Title$
1325    PRINT "POLING DATE: ";Date$
1340    PRINT LIN(1);"    RING      DAY      CAP        K        DF      FM
    FN        T "
1350 Ta11: X=-1
1360    MAT Ckf=(0)
1370    Ckf=0
1380    FOR I=1 TO 6
1390    Stat(I,1)=1E35
1400    Stat(I,2)=-1E35
1410    Stat(I,3)=Stat(I,4)=0
1420    NEXT I
1430 Ta12:  Y=1E35
1440    FOR J=1 TO Nring
1450    IF (Ser(J)<=X) OR (Ser(J)>Y) THEN Ta13
1460    I=J
1470    Y=Ser(J)
1480 Ta13:  NEXT J
1490    IF Y=1E35 THEN Ta20
1500    X=Y
1510    READ #1,I+Recplus;Dat(*)
1520    IF Nostat(I) THEN Ta14
1530    Ckf=Ckf+1
1540    Ckf(Ckf,1)=Dat(1,2)
1550    Ckf(Ckf,2)=Dat(1,3)
1560    Ckf(Ckf,3)=Dat(1,5)
1570    Ckf(Ckf,4)=Dat(2,2)
1580    Ckf(Ckf,5)=Dat(2,3)
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1590   Ckf(Ckf,6)=Dat(2,5)
1600   FOR K=1 TO 6
1610   IF Ckf(Ckf,K)<Stat(K,1) THEN Stat(K,1)=Ckf(Ckf,K)
1620   IF Ckf(Ckf,K)>Stat(K,2) THEN Stat(K,2)=Ckf(Ckf,K)
1630   Stat(K,3)=Stat(K,3)+Ckf(Ckf,K)
1640   Stat(K,4)=Stat(K,4)+Ckf(Ckf,K)^2
1650   NEXT K
1660 Ta14:  IF Opt=9 THEN Ta12
1665   PRINT USING "#,10D";Ser(I)
1670   PRINT USING Ta15;CHR$(32+10*Nostat(I))&" ",Dat(1,1),Dat(1,2),Dat(1,3),Dat(
1,4),Dat(1,5),Dat(1,6),Dat(1,7)
1680   PRINT USING Ta15;"                 ",Dat(2,1),Dat(2,2),Dat(2,3),Dat(2,4),Dat(2,
5),Dat(2,6),Dat(1,7)
1690   PRINT
1700   GOTO Ta12
1710 Ta15:  IMAGE K,3Z,4X,5D,4X,D.4D,4X,D.4D,5X,5D,5X,5D,5X,3D
1720 Ta20:  IF Opt=5 THEN PRINT LIN(2)
1725   IF Ckf=0 THEN Ta95
1730   FOR I=1 TO 6
1740   IF Ckf<>1 THEN Stat(I,4)=SQR((Stat(I,4)-Stat(I,3)^2/Ckf)/(Ckf-1))
1750   IF Ckf=1 THEN Stat(I,4)=0
1760   Stat(I,3)=Stat(I,3)/Ckf
1770   NEXT I
1771   IF Opt=9 THEN Ta99
1780   FOR I=1 TO 3
1790   PRINT
1800   IF I=1 THEN PRINT USING "#,K";"    CAP"
1810   IF I=2 THEN PRINT USING "#,K";"     K"
1820   IF I=3 THEN PRINT USING "#,K";"     FM"
1830   PRINT TAB(24);"MIN";TAB(36);"MAX";TAB(51);"MEAN";TAB(66);"STD DEV"
1840   FOR J=0 TO 3 STEP 3
1850   IF J=0 THEN PRINT USING "#,K";"FIRST DATA SET "
1860   IF J=3 THEN PRINT USING "#,K";"SECOND DATA SET"
1870   PRINT TAB(18);DROUND(Stat(I+J,1),8);TAB(30);DROUND(Stat(I+J,2),8);TAB(45);
DROUND(Stat(I+J,3),8);TAB(60);DROUND(Stat(I+J,4),8)
1880   NEXT J
1890   NEXT I
1900 Ta95:  PRINTER IS 16
1901   PAUSE
1910 Ta99:   RETURN
1920 ! -----------------------------------------------------------
1930 Call_barplot:  IF Ckf THEN Cb10
1940   PRINT "THERE IS NO DATA BASE FOR MAKING A BAR PLOT AT THIS TIME."
1950   PRINT "ACCESS OPTION 5 TO CREATE A DATA BASE AND CALCULATE STATISTICS."
1960   GOTO Cb99
1970 Cb10:  GOSUB Table
1975   CALL  Barplot(Ckf,Ckf(*),Stat(*),File$)
1980 Cb99:  RETURN
1990 ! -----------------------------------------------------------
2000 Rcat:  IF File$<>"" THEN Rca10
2010   PRINT "NO FILE HAS BEEN SELECTED."
2020   GOTO Rca99
2030 Rca10:   CALL Ringcat(File$,Nring,Title$,Date$,Ser(*),Nostat(*))
2040 Rca99:  RETURN
2050 ! -----------------------------------------------------------
2060 Statdelete:  IF File$<>"" THEN Sd10
2070   PRINT "NO FILE HAS BEEN SELECTED FOR PRINTING AND STATISTICAL ANALYSIS."
2080   GOTO Sd99
2090 Sd10:   CALL Ringselect(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*))
2100   IF Ring=0 THEN Sd99
2110   Nostat(Ring)=1
2120   PRINT "RING";Ser(Ring);"DELETED FROM STATISTICAL CALCULATIONS."
2130 Sd99:   RETURN
2140 ! -----------------------------------------------------------
2150 Statrestore:  IF File$<>"" THEN Sr10
2160   PRINT "NO FILE HAS BEEN SELECTED FOR PRINTING AND STATISTICAL ANALYSIS."
```
21

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2170   GOTO Sr99
2180 Sr10:   CALL Ringselect(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*))
2190   Nostat(Ring)=0
2200   PRINT "RING";Ser(Ring);"RESTORED TO STATISTICAL CALCULATIONS."
2210 Sr99:   RETURN
2220 ! ------------------------------------------------------------------
2230 Plot: CALL Fileselect(File$,#1,Nring,Title$,Date$,Ser(*),Recplus,Nostat(*))
2240   CALL Ringselect(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*))
2241   PRINT PAGE
2250   IF Ring=0 THEN P199
2260   PLOTTER IS 13,"GRAPHICS"
2270   GRAPHICS
2280   LOCATE 18,118,8,98
2290   SCALE 0,3,0,7
2300   AXES 1,1,0,0
2310   LORG 2
2320   CSIZE 3.3
2330   MOVE -.48,1.5
2340   LABEL USING "K";"K"
2350   MOVE -.48,3.5
2360   LABEL USING "K";"FR (Hz)"
2370   MOVE -.48,5.5
2380   LABEL USING "K";"CAP (pF)"
2390   LORG 6
2400   FOR I=0 TO 3
2410   MOVE I,-.05
2420   LABEL USING "K";"1"&RPT$("0",I)
2430   NEXT I
2440   MOVE 1.5,-.3
2450   LABEL USING "K";"DAYS"
2460   LORG 3
2470   MOVE 0,-.4
2480   LABEL USING "K,K";"FILE: ",File$
2490   LORG 9
2500   MOVE 3,-.4
2510   LABEL USING "K,10D";"RING: ",Ser(Ring)
2520   FOR I=20 TO 90 STEP 10
2530   FOR J=-1 TO 1
2540   X=LGT(I)+J
2550   MOVE X,0
2560   DRAW X,.05
2570   NEXT J
2580   NEXT I
2581   READ #1,Ring+Recplus;Dat(*)
2590   X0=LGT(Dat(1,1))
2600   X1=LGT(Dat(2,1))
2610   D0=X0/(X1-X0)
2620   D1=(3-X1)/(X1-X0)
2630   FOR I=1 TO 3
2640   ON I GOTO P120,P125,P130
2650 P120:  J=3
2651   P=-2
2670   GOTO P135
2680 P125:  J=5
2681   P=3
2700   GOTO P135
2710 P130:  J=P=2
2720 P135:  D=Dat(2,J)-Dat(1,J)
2721 ! P=INT(LGT(ABS(D)))+1
2730   Y0=Dat(1,J)-D0*D
2740   Y1=Dat(2,J)+D1*D
2741   P=INT(LGT(ABS(Y0-Y1)*.4))+1
2750 ! Y=(Y0+Y1)/2
2751    Y=(Dat(1,J)+Dat(2,J))/2
2760   Y=10^P*INT(Y/10^P)
2770   SCALE 0,3,Y-(2*I-1)*10^P,Y+(8-2*I)*10^P
```

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```
2780   LORG 8
2790   MOVE -.03,Y
2800   LABEL USING "K";Y
2810   MOVE -.03,Y+10^P
2820   LABEL USING "K";Y+10^P
2830   LORG 5
2840   FOR K=1 TO 2
2850   MOVE LGT(Dat(K,1)),Dat(K,J)
2860   LABEL USING "K";"X"
2870   NEXT K
2880   MOVE 0,Y0
2890   DRAW 3,Y1
2900   IF Y1+Y0<>0 THEN Perdecade=(Y1-Y0)/3/((Y1+Y0)/2)*100      ! CHANGE PER DECAD
E CALCULATION
2905   IF Y1+Y0=0 THEN Perdecade=0
2930   MOVE 2,(Y0+Y1)/2+.4*10^P
2940   CSIZE 2.5
2950   LABEL USING "K,K";PROUND(Perdecade,-1)," PERCENT PER DECADE"
2960   CSIZE 3.3
2970   NEXT I
2980   PAUSE
2990   EXIT GRAPHICS
3000 P199:   RETURN
3010 ! ----------------------------------------------------
3020 Fileselect: SUB Fileselect(File$,#1,Nring,Title$,Date$,Ser(*),Recplus,Nosta
t(*))
3030 OPTION BASE 1
3040 X=1+(File$<>"")
3050   IF X=2 THEN Fs20
3060 Fs10: INPUT "ENTER FILE NAME WITH MASS STORAGE DEVICE",F$
3070   GOTO Fs30
3080 Fs20:   PRINT PAGE;"CURRENT FILE: ";File$
3090   F$=File$
3100   INPUT "PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE",F$
3110   IF F$=File$ THEN Fs99
3120 Fs30:   PRINT "ATTEMPTING TO OPEN FILE ";F$
3130   ON ERROR GOTO Fs40
3140   ASSIGN #1 TO F$
3150   OFF ERROR
3160   READ #1,1;Nring,Title$,Date$
3170   REDIM Ser(Nring)
3180   READ #1,2
3190   READ #1;Ser(*)
3200   Recplus=1+INT(Nring/16)+(Nring MOD 16>0)
3210   MAT Nostat=(0)
3220   GOTO Fs50
3230 Fs40: OFF ERROR
3240   PRINT LIN(1);"ERROR";ERRN;"DURING ATTEMPT TO OPEN FILE ";F$
3250   ON X GOTO Fs10,Fs20
3260 Fs50: File$=F$
3270 Fs99: Recplus=1+INT(Nring/16)+(Nring MOD 16>0)
3275   SUBEND
3280 ! ----------------------------------------------------
3290 Ringcat: SUB Ringcat(File$,Nring,Title$,Date$,Ser(*),Nostat(*))
3300 OPTION BASE 1
3310 Rc10:X$=""
3320 INPUT "HARDCOPY PRINTOUT (Y or N)?",X$
3330 IF (X$<>"Y") AND (X$<>"N") THEN Rc10
3340   PRINTER IS 16*(X$="N")
3341   PRINT LIN(2);"FILE: ";File$
3342   PRINT Title$
3343   PRINT "POLING DATE: ";Date$
3350   PRINT LIN(1);"FILE ";File$;" CONTAINS DATA FOR THE FOLLOWING RING SERIAL N
UMBERS:";LIN(1)
3353   X=-1
3357 Rc20:   Y=1E35
```

```
3360   FOR I=1 TO Nring
3370   IF (Ser(I)<=X) OR (Ser(I)>Y) THEN Rc30
3371   J=I
3372   Y=Ser(I)
3380 Rc30: NEXT I
3381   IF Y=1E35 THEN Rc90
3382   X=Y
3383   Z$=" "&VAL$(Ser(J))
3384   IF Nostat(J) THEN Z$[1,1]="*"
3387   PRINT Z$,
3388   GOTO Rc20
3390 Rc90: PRINT
3400   PRINTER IS 16
3410 Rc99: SUBEND
3420   ! ------------------------------------------
3430 Ringselect:  SUB Ringselect(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*))
3440   OPTION BASE 1
3450   PRINT
3460 Rs10:  Ser=-1
3470   INPUT "ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)",Ser
3480   ON SGN(Ser)+2 GOTO Rs10,Rs15,Rs20
3490 Rs15: CALL Ringcat(File$,Nring,Title$,Date$,Ser(*),Nostat(*))
3500 GOTO Rs10
3510 Rs20: FOR Ring=1 TO Nring
3520   IF Ser(Ring)=Ser THEN Rs99
3530   NEXT Ring
3540   Ring=0
3550   PRINT LIN(1);"SERIAL NUMBER";Ser;"NOT FOUND IN FILE ";File$
3560 Rs99:  SUBEND
3570 ! ------------------------------------------
3580 Barplot: SUB Barplot(Ckf,Ckf(*),Stat(*),File$)
3590 DEG
3600   OPTION BASE 1
3610   DIM Bins(25)
3611   PRINT PAGE
3620 Bp10:  K=0
3630   INPUT "ENTER 1 TO PLOT CAP; 2 TO PLOT K; 3 TO PLOT FR",K
3640   IF (K<1) OR (K>3) THEN Bp10
3650   FOR Dataset=1 TO 2
3660   D=Dataset*3-3
3670   Dx=Stat(K+D,2)-Stat(K+D,1)
3680   Dtic=10^INT(LGT(Dx)-1)
3690   IF Dx/Dtic<20 THEN Bp20
3700   Dtic=Dtic*2
3710   IF Dx/Dtic>=20 THEN Dtic=Dtic*2.5
3720 Bp20:  Bmin=PROUND(Stat(K+D,1)/Dtic,0)
3730   Bmax=PROUND(Stat(K+D,2)/Dtic,0)
3740   REDIM Bins(1+Bmax-Bmin)
3750   MAT Bins=(0)
3760   Ymax=0
3770   FOR I=1 TO Ckf
3780   B=PROUND(Ckf(I,K+D)/Dtic,0)+1-Bmin
3790   Bins(B)=Bins(B)+1
3800   IF Bins(B)>Ymax THEN Ymax=Bins(B)
3810   NEXT I
3820   Ymax=MAX(5,Ymax)
3830   PLOTTER IS 13,"GRAPHICS"
3840   GRAPHICS
3850   LOCATE 15,110,25,95
3860   Xmin=Dtic*(Bmin-1)
3870   Xmax=Dtic*(Bmax+1)
3880   SCALE Xmin,Xmax,0,Ymax
3890   Ytic=1+(Ymax>50)
3900   AXES Dtic,Ytic,Xmin,0,5,5
3910   CSIZE 2.5
3920   LORG 5
```

```
3930    MOVE (Bmin-1)*Dtic,-.028*Ymax
3940    LABEL USING "K";(Bmin-1)*Dtic
3950    FOR I=Bmin TO Bmax
3960    CLIP (I-.5)*Dtic,(I+.5)*Dtic,0,Bins(i-Bmin+1)
3970    FRAME
3980    IF (I-Bmin+1) MOD 5 THEN Gr20
3990    MOVE I*Dtic,-.028*Ymax
4000    LABEL USING "K";I*Dtic
4010 Gr20:  NEXT I
4020    MOVE Dtic*(Bmin+Bmax)/2,-.0654*Ymax
4030    CSIZE 2.7,.8
4040    Y$="FIRST"
4050    IF Dataset=2 THEN Y$="SECOND"
4060    X$="CAP"
4070    IF K=2 THEN X$="K"
4080    IF K=3 THEN X$="FR"
4090    LABEL USING "K";"FILE "&File$&"   "&X$&" ("&Y$&" DATA SET)"
4100    CSIZE 2.5
4110    LORG 8
4120    FOR I=0 TO Ymax STEP 5*Ytic
4130    MOVE Dtic*(Bmin-1)-.01*Dtic*(Bmax-Bmin+2),I
4140    LABEL USING "K";I
4150    NEXT I
4160    LORG 5
4170    MOVE Dtic*(Bmin-1)-.11*Dtic*(Bmax-Bmin),Ymax/2
4180    LDIR 90
4190    CSIZE 2.7,.8
4200    LABEL USING "K";"NUMBER OF OCCURANCES"
4210    LDIR 0
4220    PRINT "PRESS CONT WHEN READY"
4230    PAUSE
4240    NEXT Dataset
4250    EXIT GRAPHICS
4260    SUBEND
```